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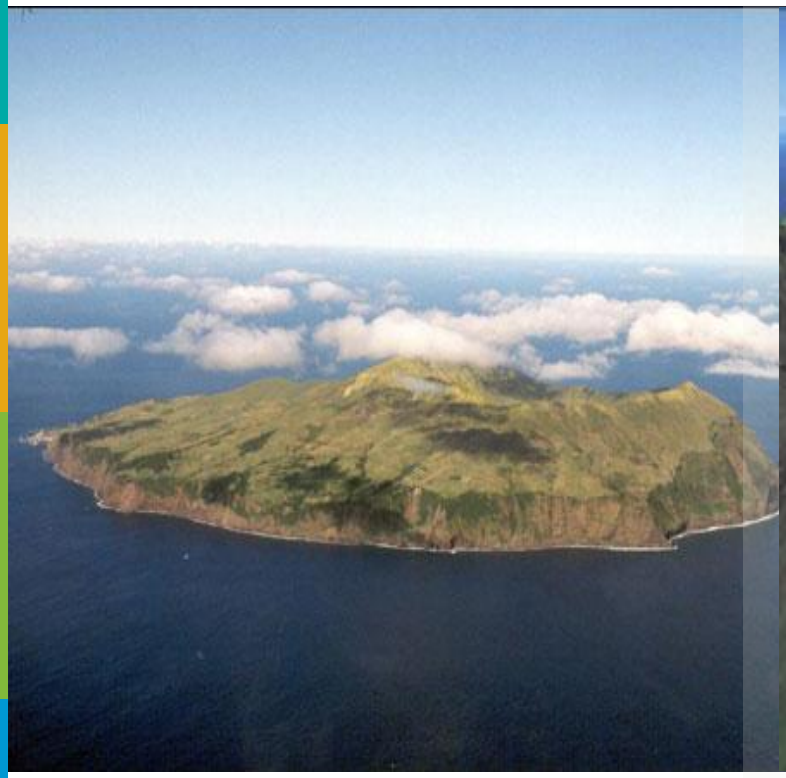
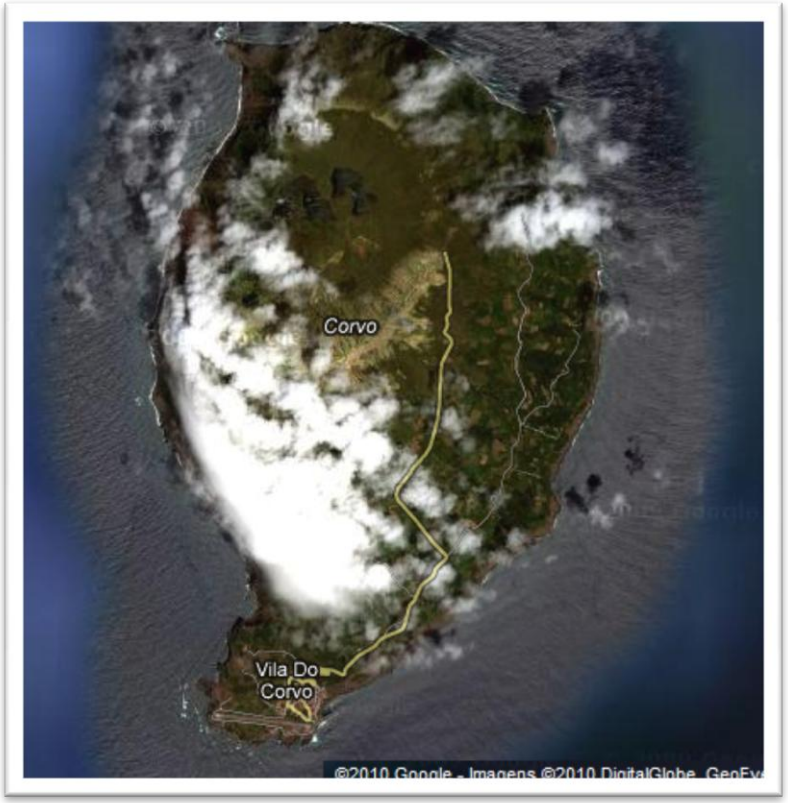
# Project Corvo:

## The new paradigm of a sustainable energy system



# Corvo Island




**Land area**: 17 km2
**Population (2008)**: 488
**Primary energy consumption (TJ)**: 21
**Electricity Consumption (2010)=1.4GWh**
**Renewables penetration in electricity**: 0%
**Number of vehicles**: 93
**Number of households**: 145
**Electricity customers**: 248

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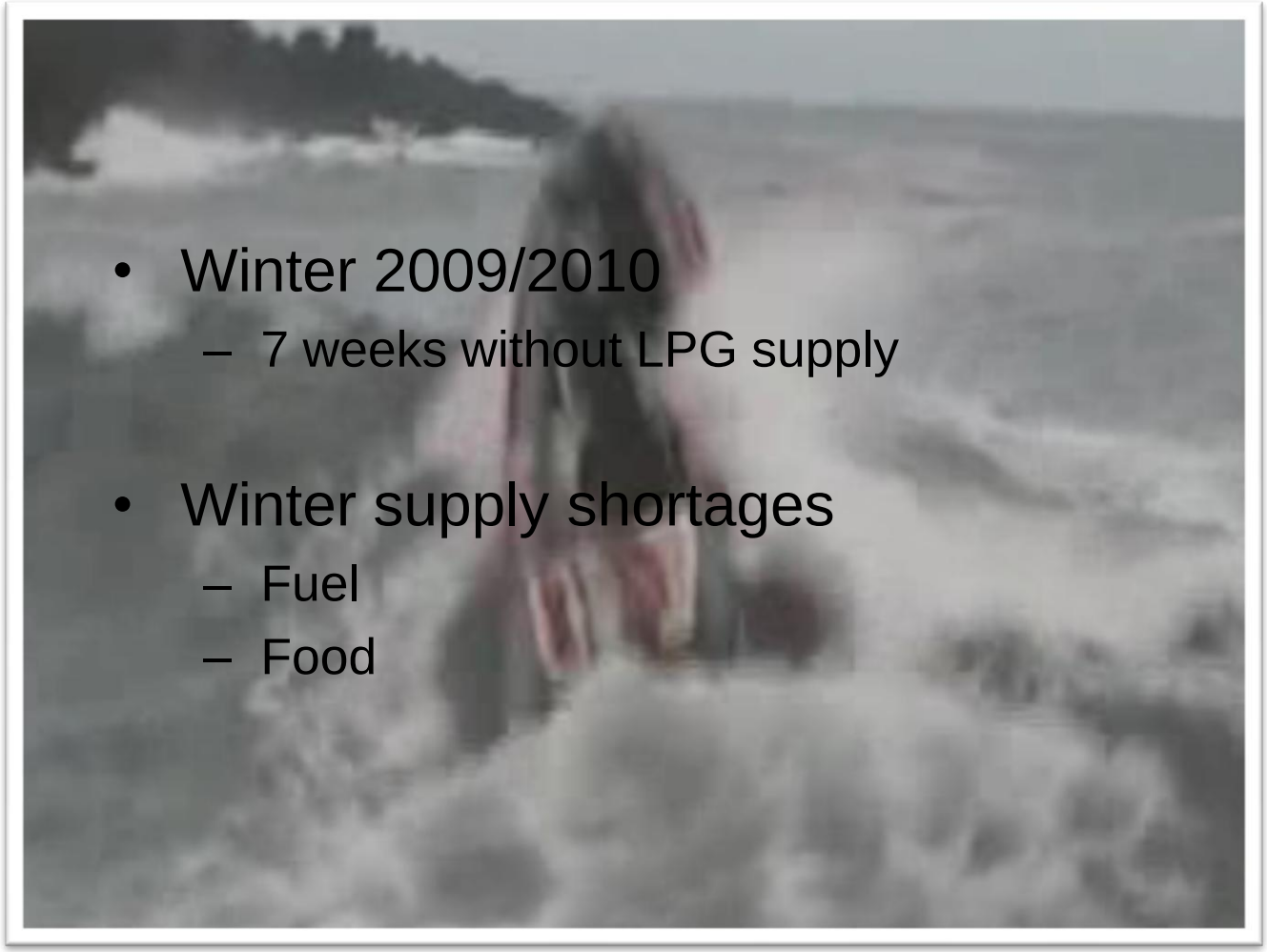
# Motivation


• Winter 2009/2010
– 7 weeks without LPG supply
• Winter supply shortages
– Fuel
– Food

# General Objectives

A. Testbed of integration of renewable energy resources (electricity, heat) and demand side management
   - Above 75% of renewable electricity
   - 0% of GPL
   - Reduce use of diesel and gasoline for transportation

B. Develop innovative products and services - Portuguese companies for export

# Project Components

1. Renewables for hot water heating
   - Solar Thermal
2. Renewables for electricity generation
   - Wind
   - Solar(?)
3. Storage
4. Demand-side management
5. Smart-grid
6. *Electric Mobility*

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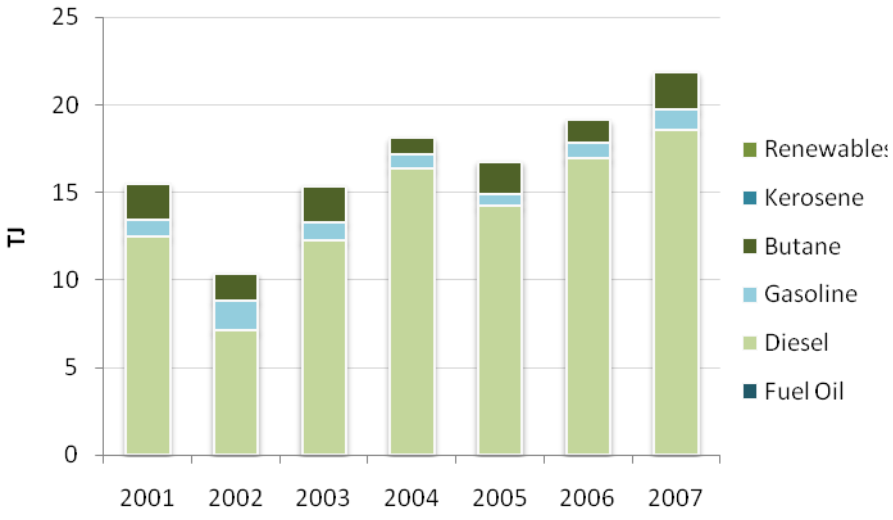
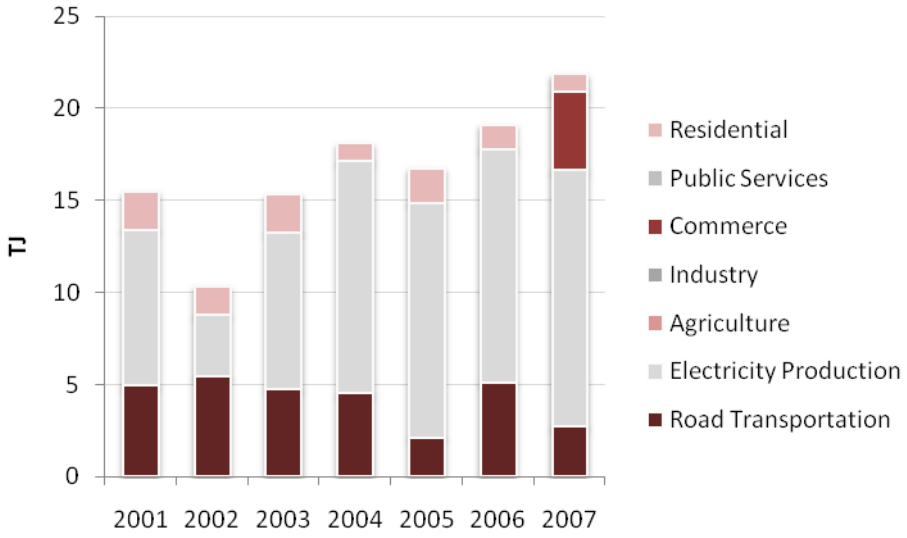
# Corvo Energy Outlook




- Fuel transport is very difficult in winter
  - Supply disruption every year (butane and diesel for vehicles)
    - Butane offset
- Annual Government support
  - GPL: 39 000 €
  - Diesel: 30 000 € electricity / 12 000 € transport

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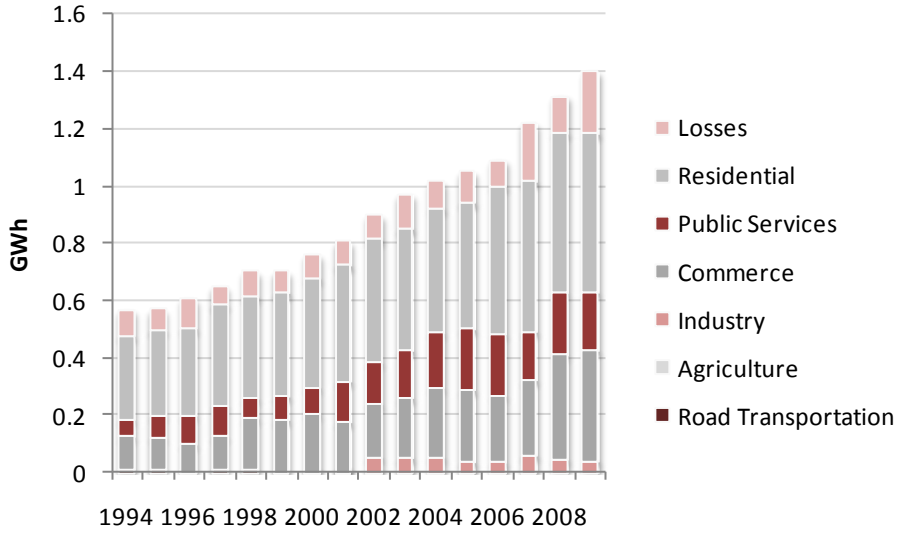
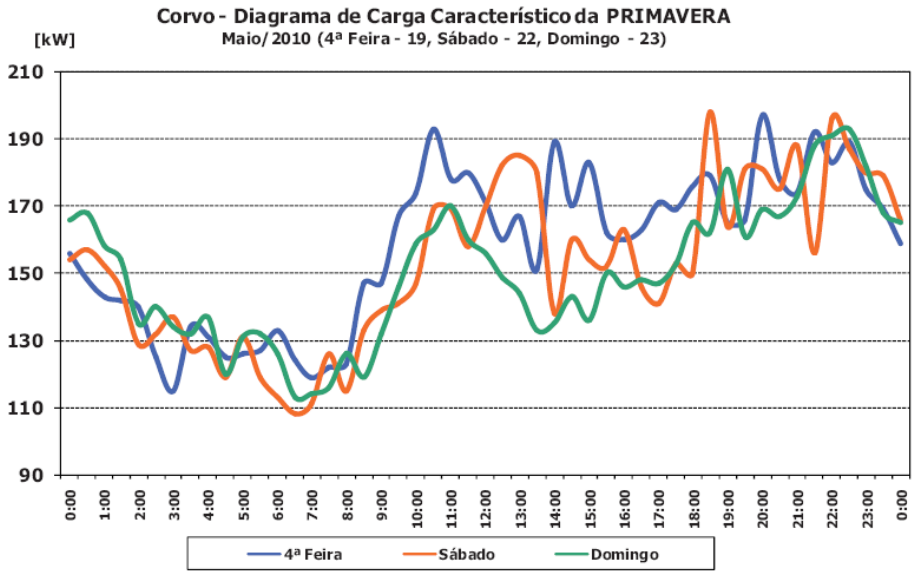
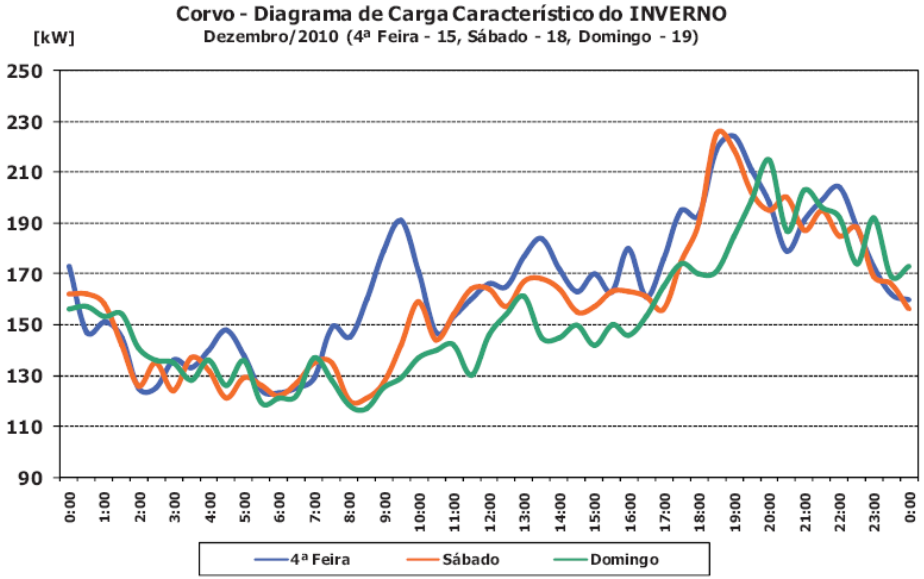
# Electricity Consumption

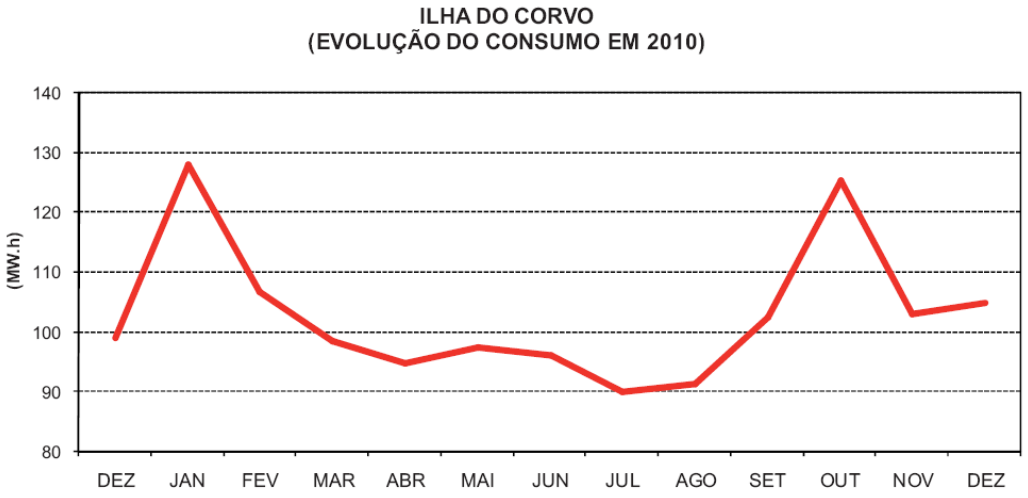


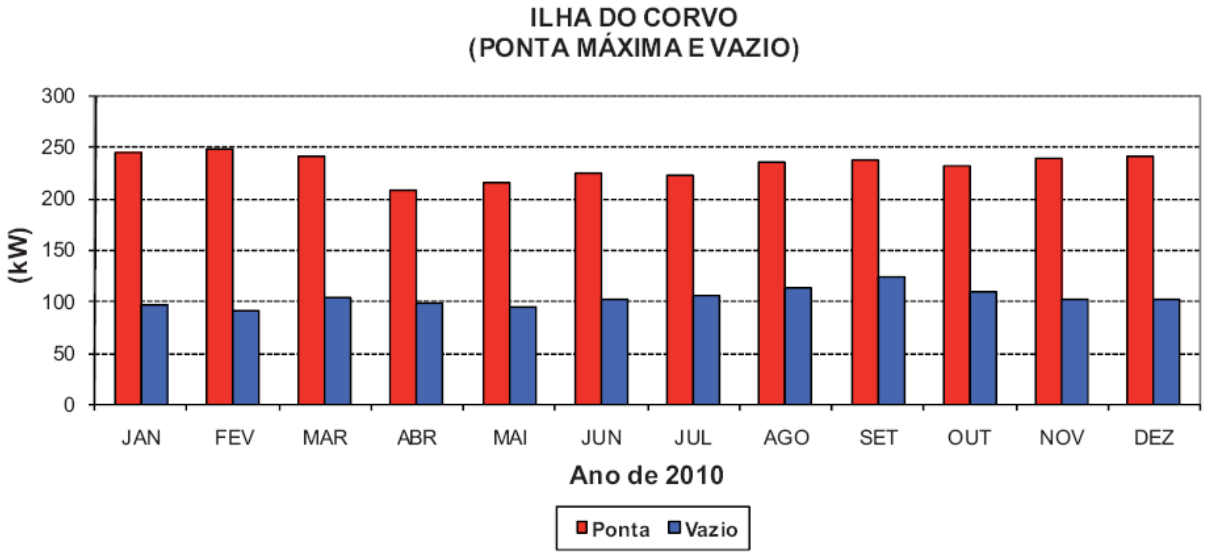

- Residential sector represents 40%



# Electricity Consumption Evolution

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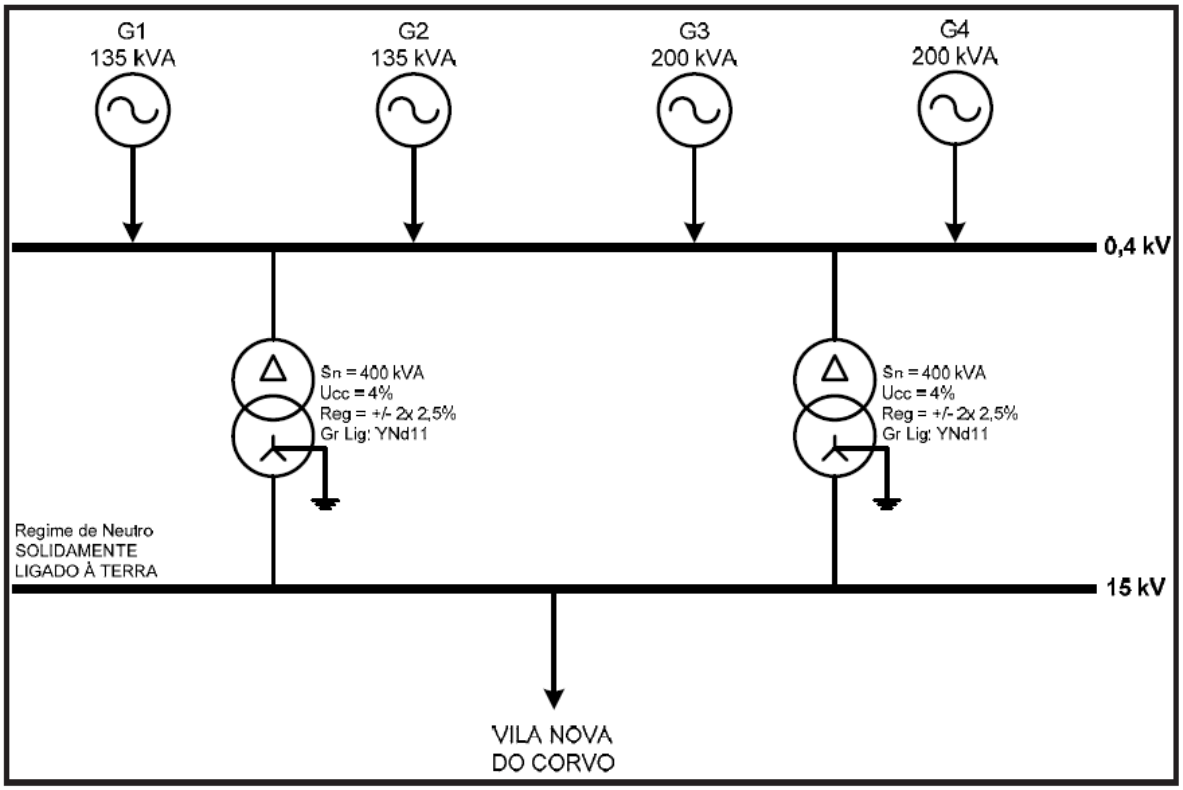
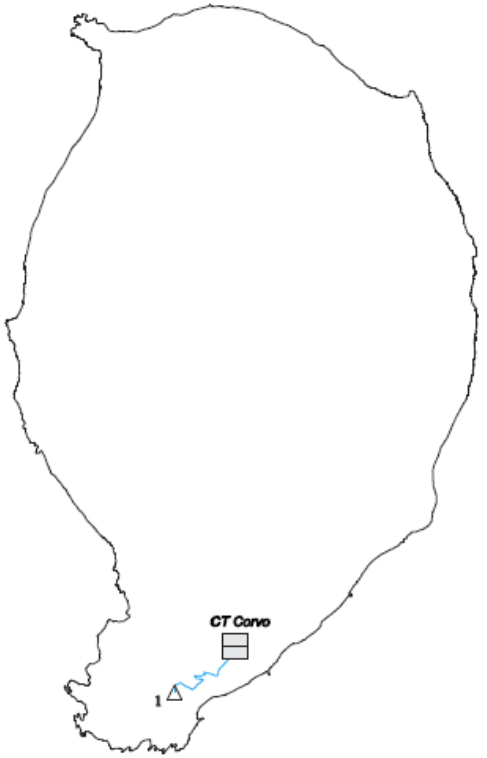
# Grid

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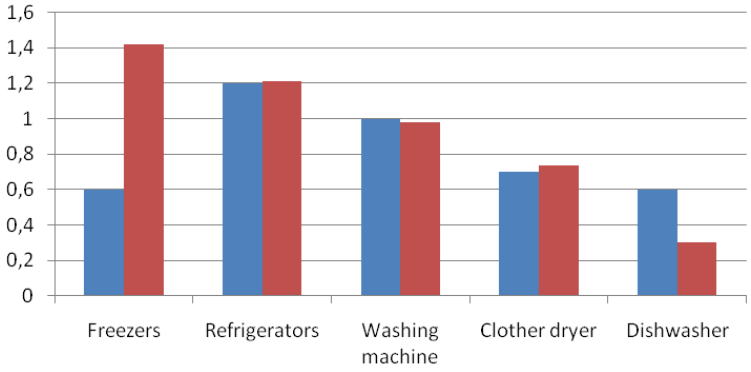
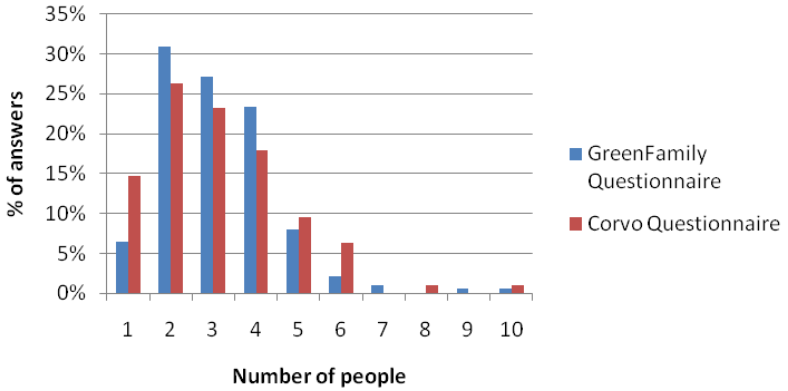
# Residential demand characterization survey - results

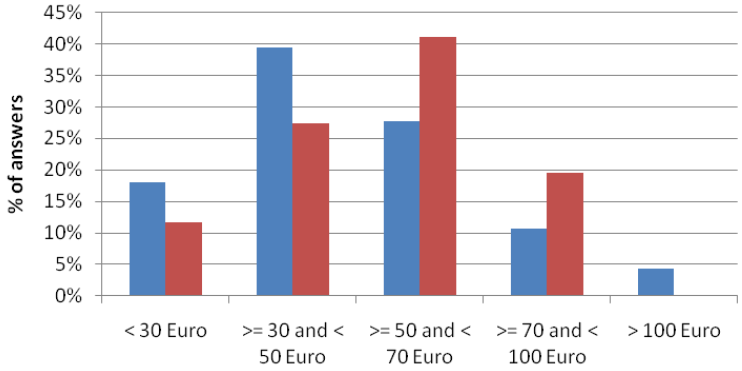
## Number of appliances per household



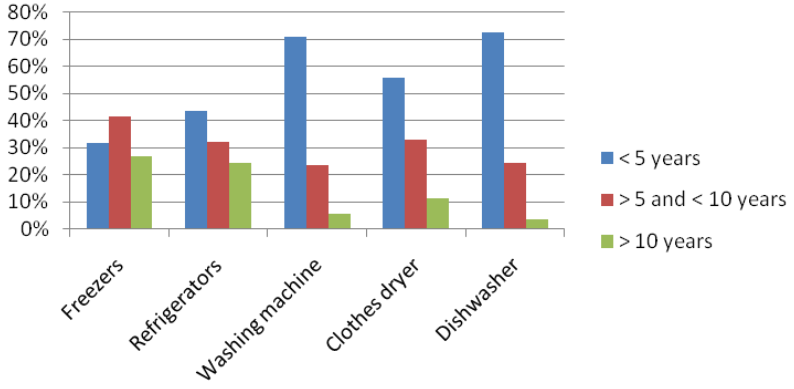

## Number of people per household




## Household electricity costs




## Age of the existing appliances

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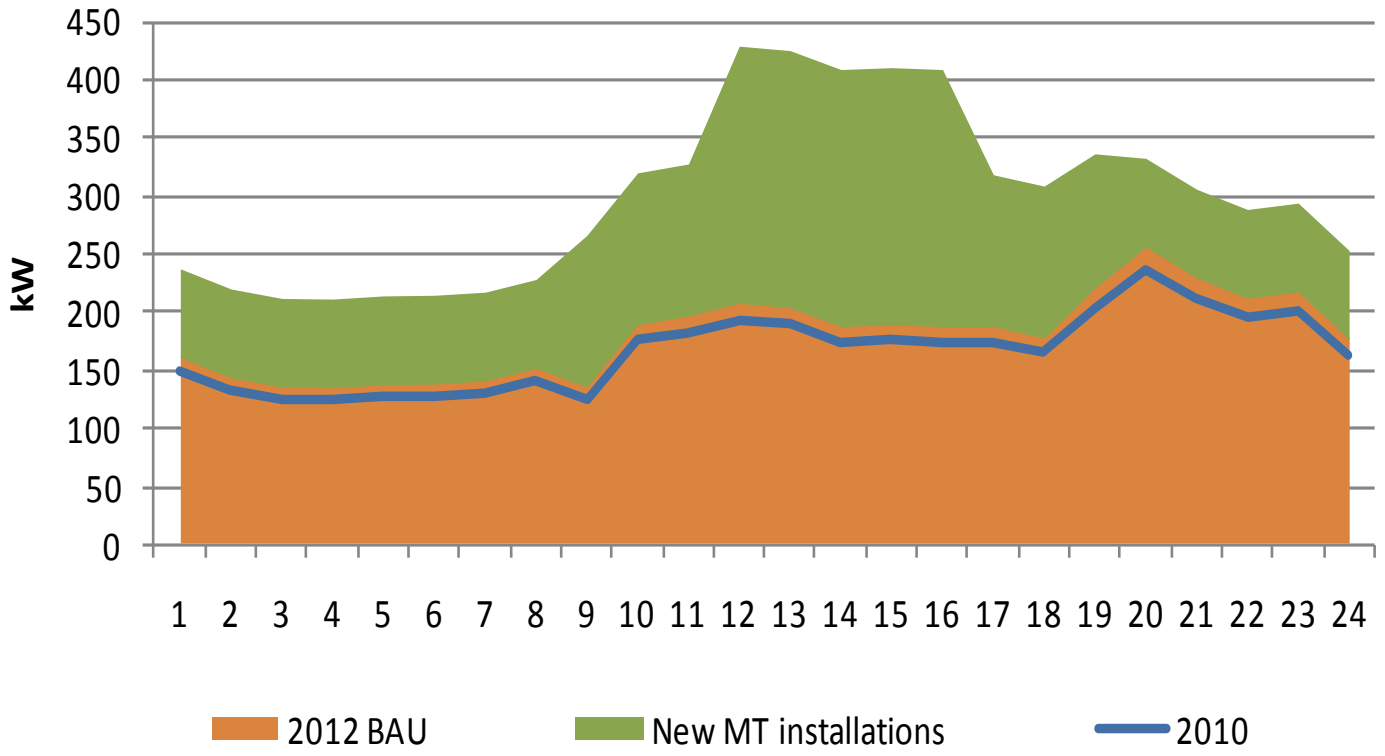
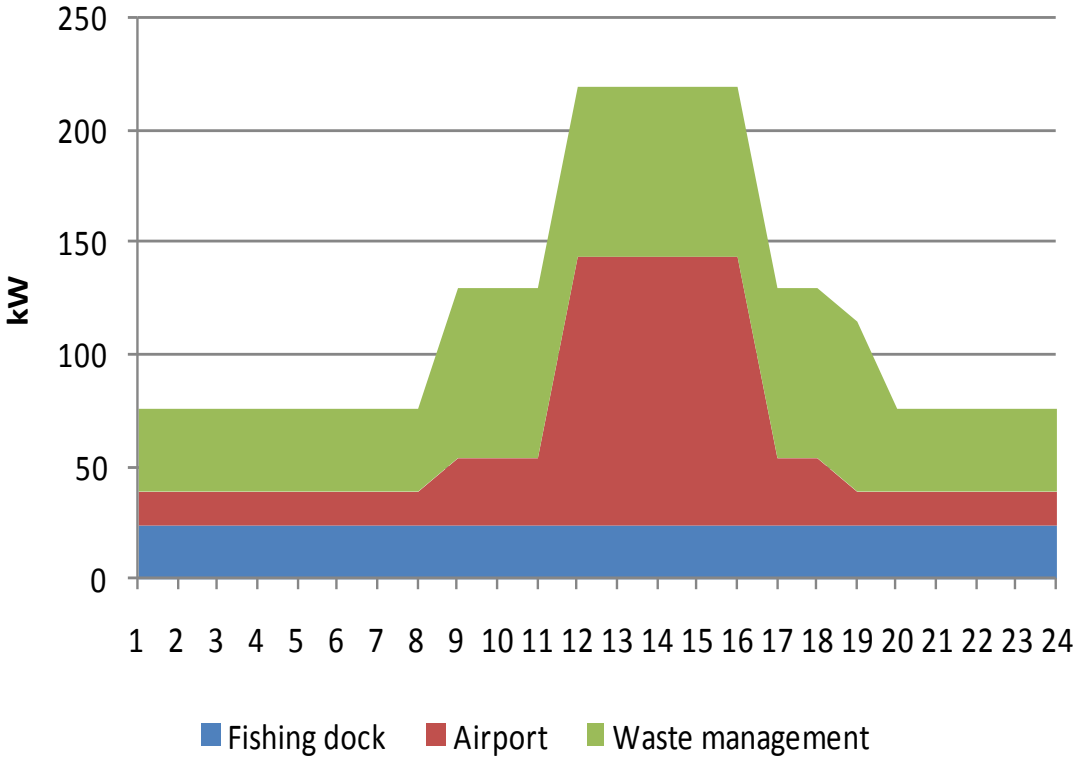
# Expected load diagram in 2012



# New electric loads (already planned)

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# Towards 100% Renewable Energy

1. Solar thermal for Hot Water
   - New electricity demand: 316 kWh /day
   - Demand Pattern: 200 kWh7H-9H , 116kWh 19H-21H
2. Electrify stoves and ovens
   - New electricity demand: 165MWh /year, 450 kWh /day
   - Demand Pattern: 200kWh12H-14H , 250kWh19H-22H
3. Electric Vehicles
   - Demand Pattern:130kWh:23H-8H, 20kWh:11H-15H

- *Wind park + storage system [EDA]*
  - *Flywheels, Batteries, EV, HW electric boiler*

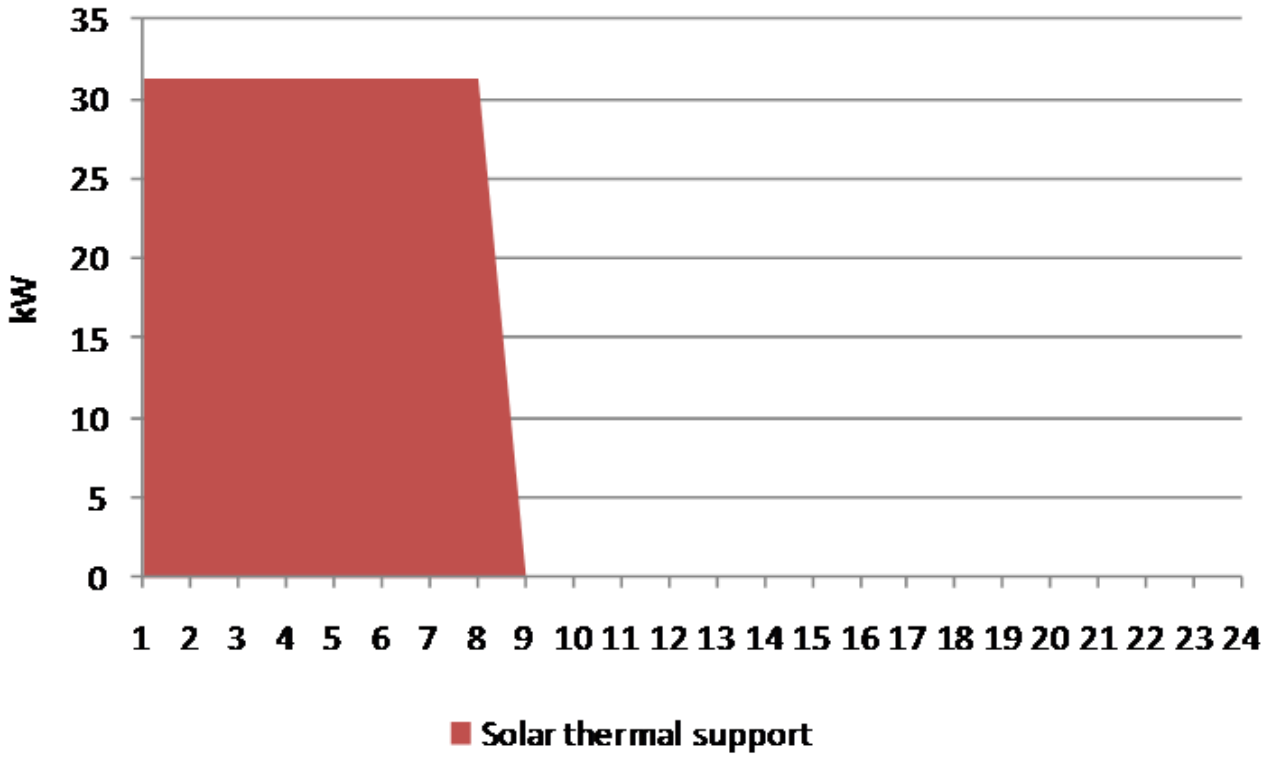
# Implementation Requirements (Households)

- 139 Solar hot water equipments (solar +heat pump)
- 139 Electric Boilers (1.2 to 2 VA)
  - New installed capacity: **250KVA**
- 139 smart plugs
- 250 smart meters
- *139 electric stoves*
- *139 electric ovens*

# Implementation Requirements (Infrastructure)

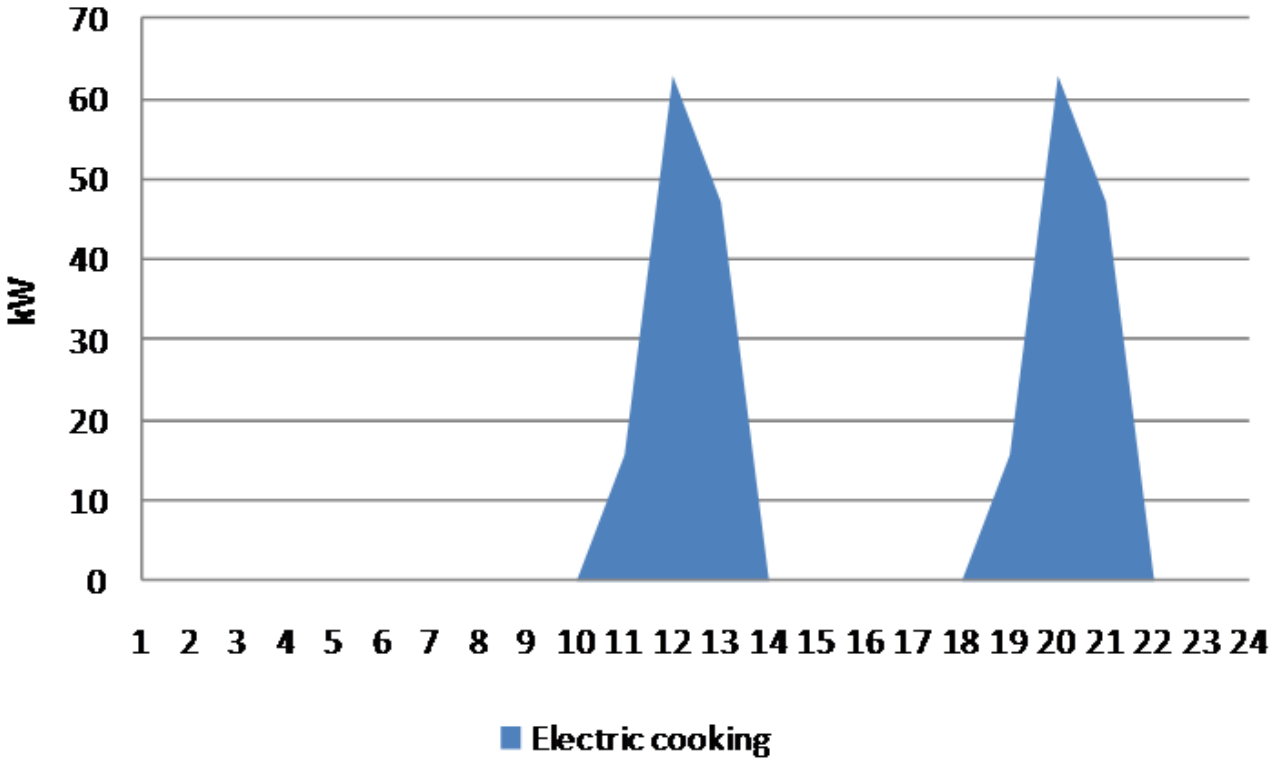
- Wind power plant (3x270 KW)
- Solar power plant (200 kW (?))
- Storage for regulation (flywheels)
- Grid uprate (powerplant and distribution network)
- Smartgrid

# Solar heating backup

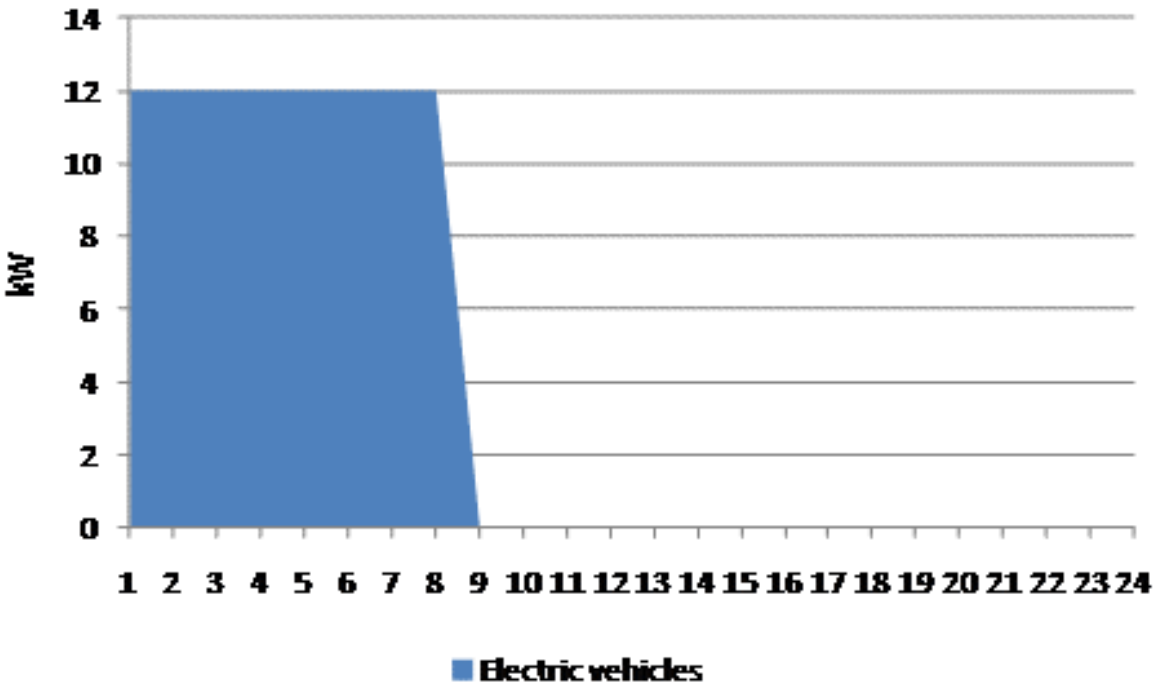



This requires demand response!

# Coking appliances



# 4 electric vehicles charging




This requires demand response!

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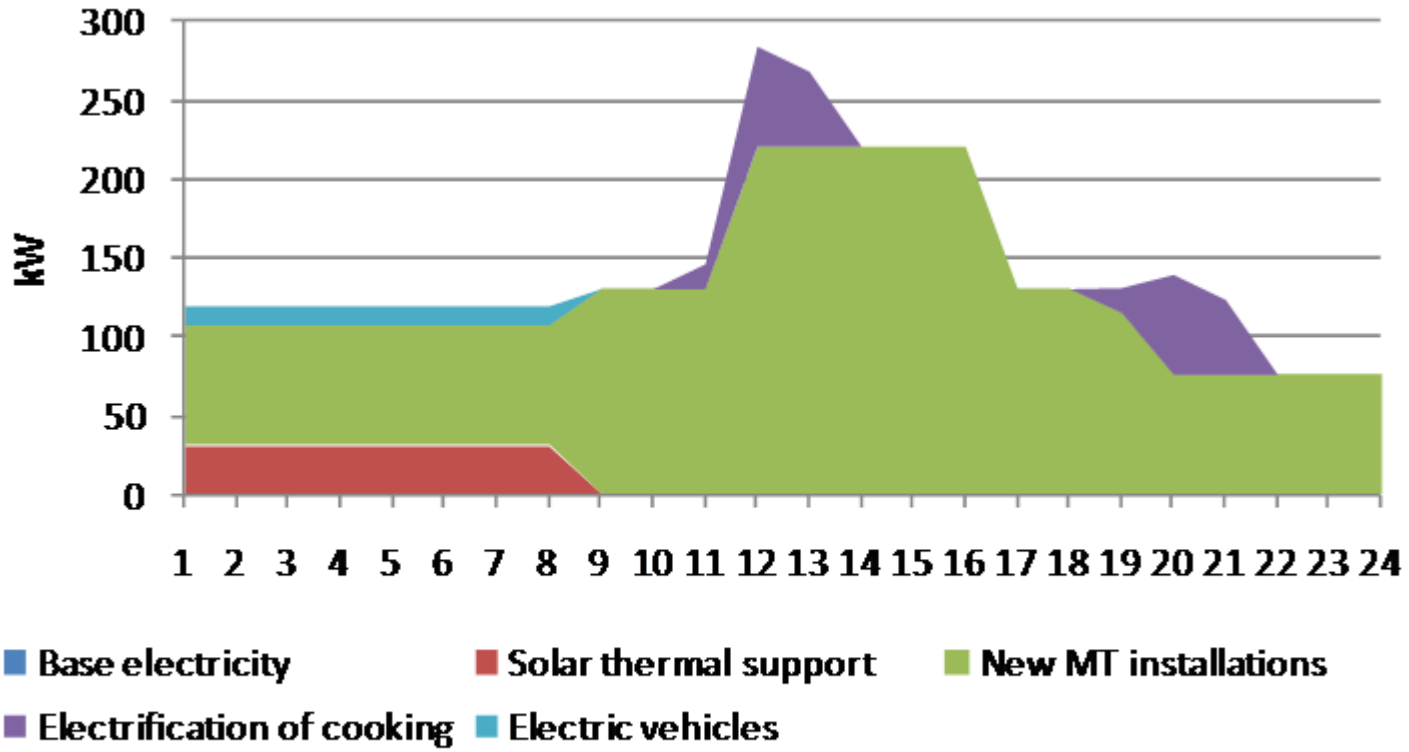
# Total additional load expected after electrification




This requires demand side management !

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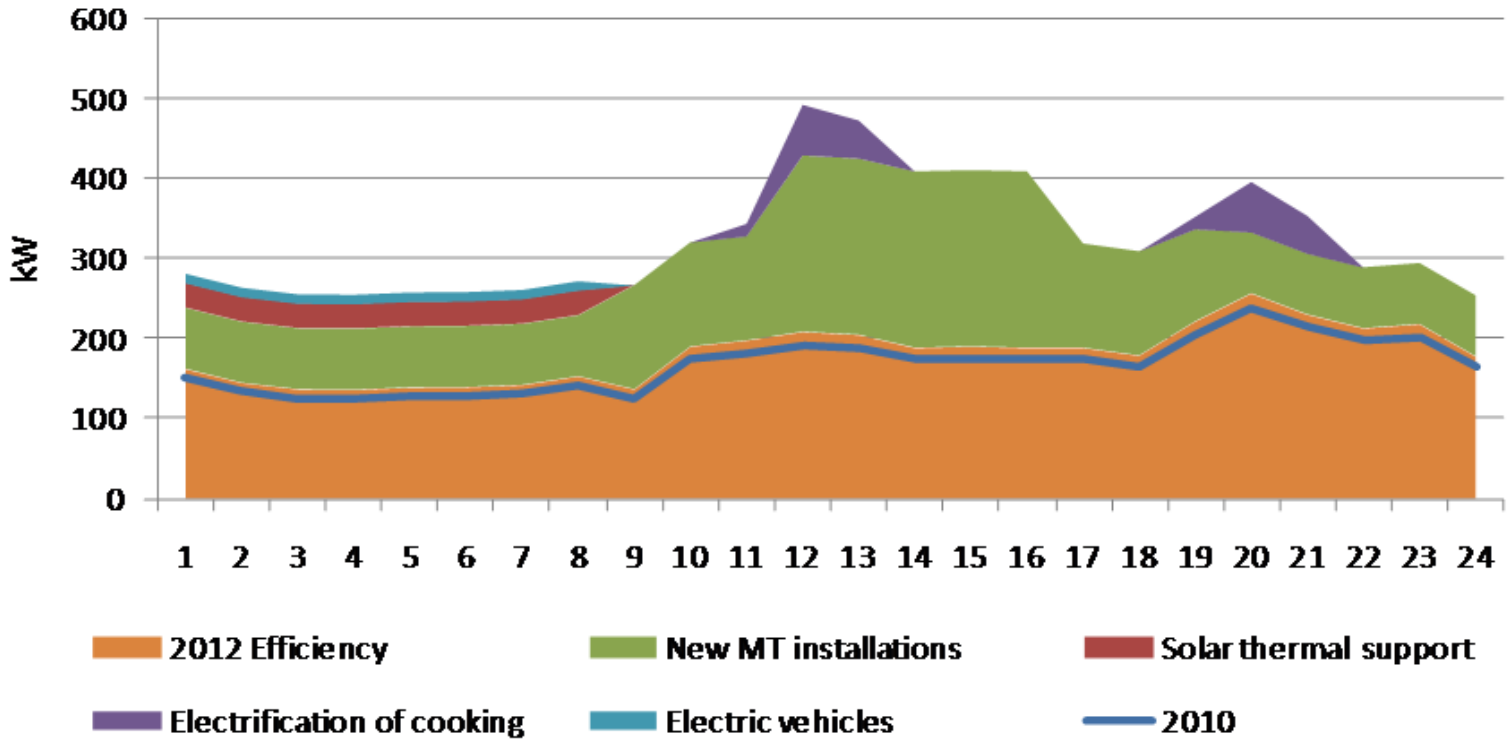
# Total load diagram after electrification

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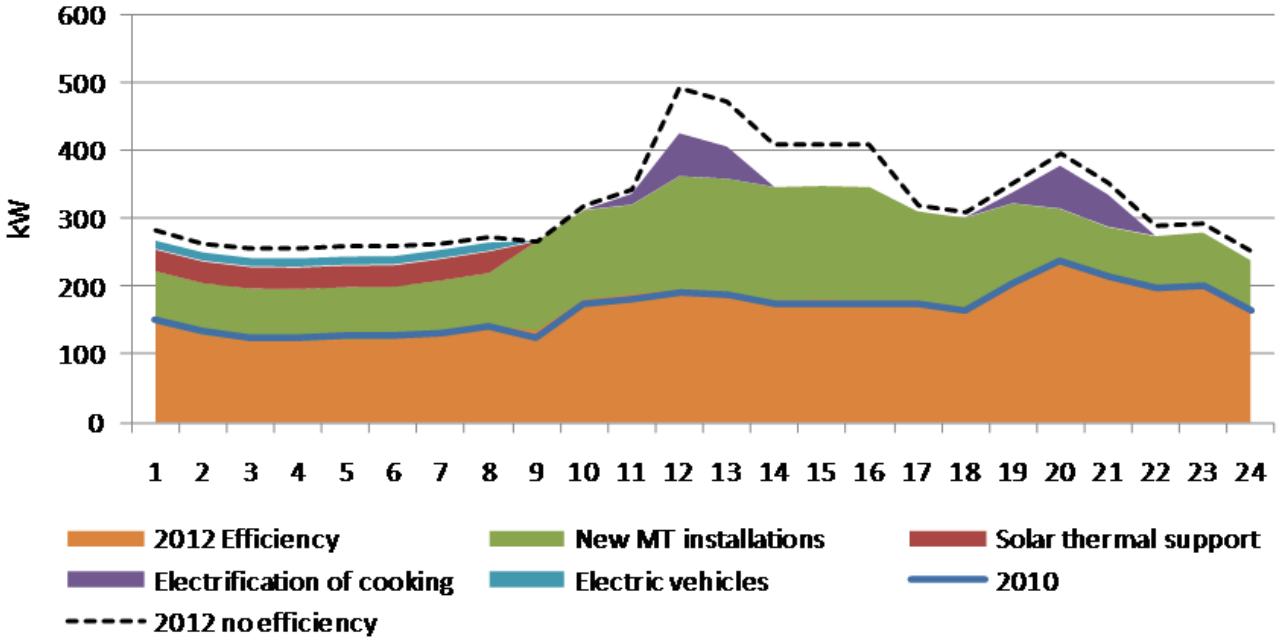
# Total load diagram with energy efficiency strategies




- Demand side management
  - Residential: solar hot water, clothes and dish washing machines demand response
  - Services (airport and waste management): operations integrated scheduling
- Replacement of fridges and public lightning

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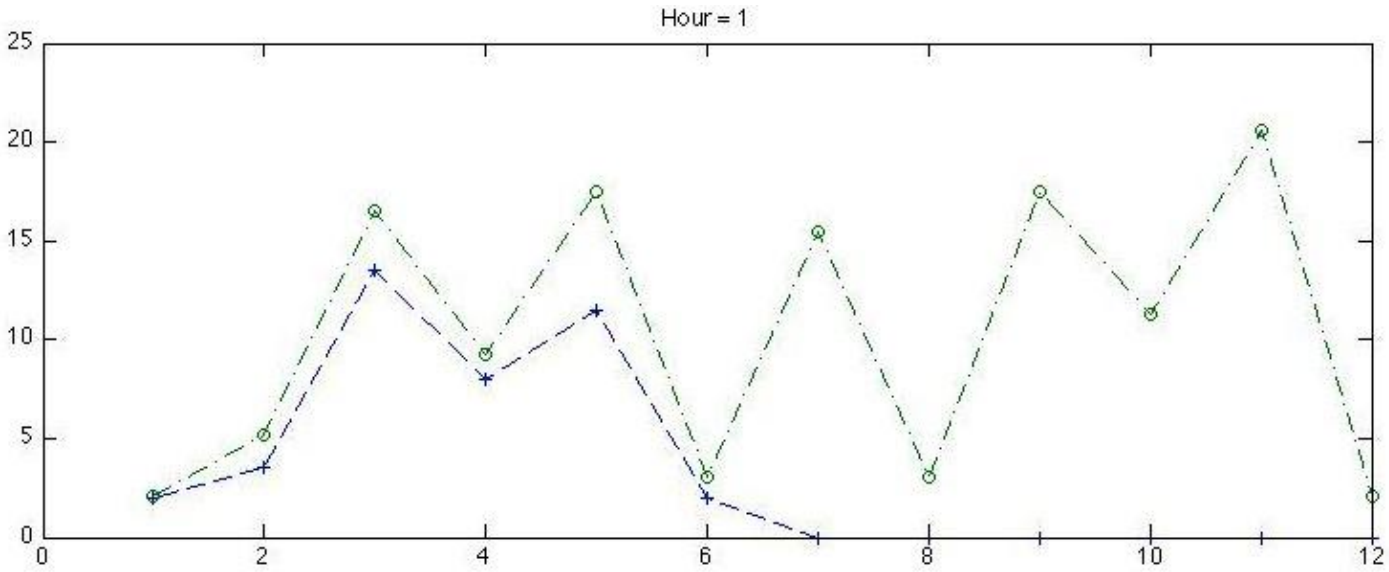
# Demand response for appliances (11 appliances)




- Usage of weather predictions
  - Wind generation and solar thermal backup
- Maximizes match between supply and demand (utility)
- Minimizes deviations from preferences (consumer)
  - : Start moment, max ending moment, no interruption of service once is started

# Demand response results

## User preferences

| 'Appliance Id' | 'Tentry' |
|---|---|
| 'obj1' | [ 0] |
| 'obj2' | [ 0] |
| 'obj3' | [ 14] |
| 'obj4' | [ 0] |
| 'obj5' | [ 0] |
| 'obj6' | [ 0] |
| 'obj7' | [ 0] |
| 'obj8' | [ 0] |
| 'obj9' | [ 7] |
| 'obj10' | [ 0] |
| 'obj11' | [ 1] |

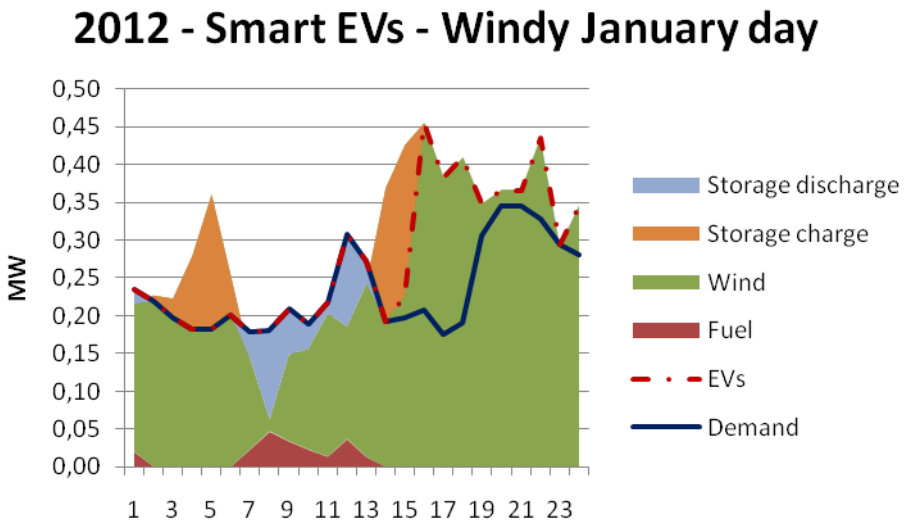
| 'Appliance Id' | 'Tlimit' |
|---|---|
| 'obj1' | [ 11] |
| 'obj2' | [ 18] |
| 'obj3' | [ 19] |
| 'obj4' | [ 7] |
| 'obj5' | [ 7] |
| 'obj6' | [ 7] |
| 'obj7' | [ 7] |
| 'obj8' | [ 8] |
| 'obj9' | [ 13] |
| 'obj10' | [ 7] |
| 'obj11' | [ 9] |

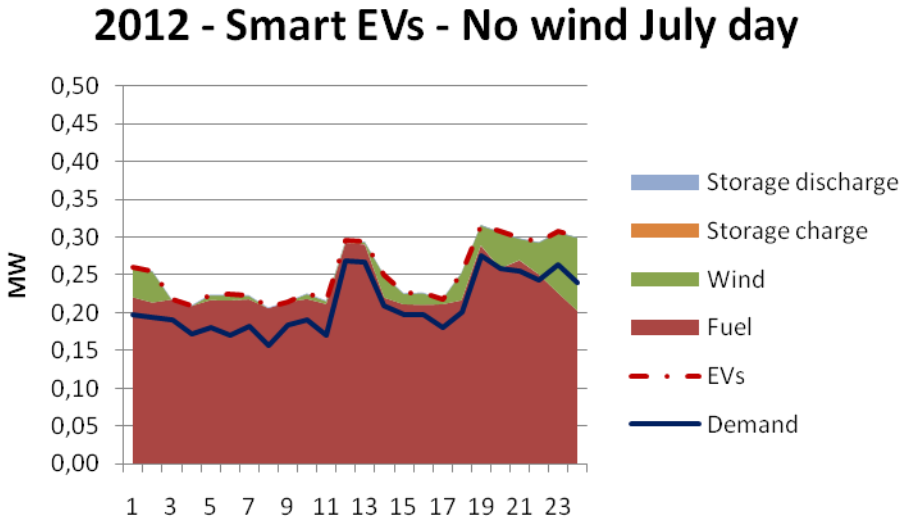
## Utility scheduling

| 'Appliance Id' | 'TSTART' |
|---|---|
| 'obj1' | [ 4] |
| 'obj2' | [ 3] |
| 'obj3' | [ 14] |
| 'obj4' | [ 2] |
| 'obj5' | [ 2] |
| 'obj6' | [ 1] |
| 'obj7' | [ 1] |
| 'obj8' | [ 3] |
| 'obj9' | [ 7] |
| 'obj10' | [ 3] |
| 'obj11' | [ 3] |

| 'Appliance Id' | 'Tfinish' |
|---|---|
| 'obj1' | [ 7] |
| 'obj2' | [ 6] |
| 'obj3' | [ 17] |
| 'obj4' | [ 4] |
| 'obj5' | [ 4] |
| 'obj6' | [ 3] |
| 'obj7' | [ 3] |
| 'obj8' | [ 6] |
| 'obj9' | [ 10] |
| 'obj10' | [ 6] |
| 'obj11' | [ 6] |

# Introducing renewables (1 MW wind+ batteries)

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# 100% renewable energy Corvo requires…

- INNOVATIVE SOLUTIONS!
  - Smart grid
    - Large penetration of renewables
  - Demand side management
    - Customers interaction
      - Behavioral changes (information, education)
      - Load management
  - Electric vehicles
    - Grid management (storage and regulation)